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Fact Sheet

POWER SECTOR OPPORTUNITIES FOR REDUCING CARBON DIOXIDE EMISSIONS: COLORADO

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WHAT WILL CO_2 STANDARDS MEAN FOR COLORADO?

President Obama announced a national climate plan in June 2013 and directed the U.S. Environmental Protection Agency (EPA) to set carbon pollution standards for the power sector. Once EPA establishes those standards, states will implement their own plans for achieving those reductions. In this fact sheet, WRI examines existing tools Colorado can use to reduce power plant emissions.

HOW COLORADO CAN REDUCE POWER SECTOR EMISSIONS

WRI analysis shows that Colorado has many opportunities to reduce carbon pollution from its power sector. Colorado is in a good position to meet moderately ambitious future emissions standards for existing power plants in the near-term. However, Colorado can achieve greater carbon pollution reductions and place itself in position to meet more stringent standards in the near- to mid-term by expanding its existing policies.

According to data from the Energy Information Administration (EIA), carbon dioxide (CO_2) emissions from Colorado's power sector were 2 percent below 2005 levels in 2011 (the most recent year with available energy data).[1] According to reference case projections based on EIA's *Annual Energy Outlook 2012* (*AEO 2012*), emissions are expected to increase to 11 percent above 2011 levels by 2030. This reference case includes the state's existing renewable

Box 1 | What's Ahead for the Power Sector?

The power sector is the leading source of carbon dioxide (CO_2) emissions in the United States, but also offers some of the most cost-effective opportunities to reduce those emissions. Despite recent decreases in power sector emissions—due to the recession, increasing competition from renewable energy and the low price of natural gas—current projections show that, absent policy action, emissions will increase in the coming decades.[2]

New Power Plants: On September 20, 2013, EPA proposed CO_2 emissions standards for new power plants.[3] These standards will provide a backstop ensuring new power plants produce significantly lower CO_2 emissions per megawatt-hour of power generation than the average existing coal plant, requiring coal plants to achieve emissions rates of 1,000 – 1,100 pounds of CO_2 per megawatt-hour (lbs. per MWh), large natural gas plants to achieve 1,000 lbs. per MWh, and smaller natural gas plants to achieve 1,100 lbs. per MWh. However, because new coal plants are unlikely to be built even in the absence of the standards—due to relatively low natural gas prices, among other factors[4]—it is unlikely that the new power plant standards will have a significant impact on near-term CO_2 emissions.

Existing Power Plants: EPA also has been directed to (a) propose CO_2 emissions standards for existing power plants by June 1, 2014; (b) finalize these standards by June 1, 2015; and (c) require states to submit their proposed implementation plans by June 30, 2016. The Clean Air Act provides EPA with considerable flexibility in setting guidelines for states to meet these standards. States could be allowed to pursue a range of programs that encourage activities—such as fuel switching, dispatch of existing low-carbon power plants, increased generation by renewable sources, and energy efficiency, among other options—for meeting emissions targets. EPA also could set guidelines that allow for emissions rate averaging across power sector generation units to help meet the standard.

portfolio standard (RPS), energy efficiency resource standard (EERS; see below for more detail),[5] and coal retirements planned under the state's Clean Air-Clean Jobs Act.[6] However, we adjust the reference case to assume that to help comply with new CO_2 standards, the renewable energy generation required by the RPS occurs through in-state renewable generation as opposed to purchasing renewable energy credits generated out of state.[7]

Colorado can reduce power sector CO_2 emissions to 29 percent below 2011 levels in 2020 by achieving the targets in these existing state policies and taking advantage of the CO_2 reduction opportunities that use the existing infrastructure listed below.[8] This is equivalent to a 31 percent reduction in emissions from 2005 levels. Reductions of this magnitude would meet or exceed moderately ambitious standards for existing power plants.[9]

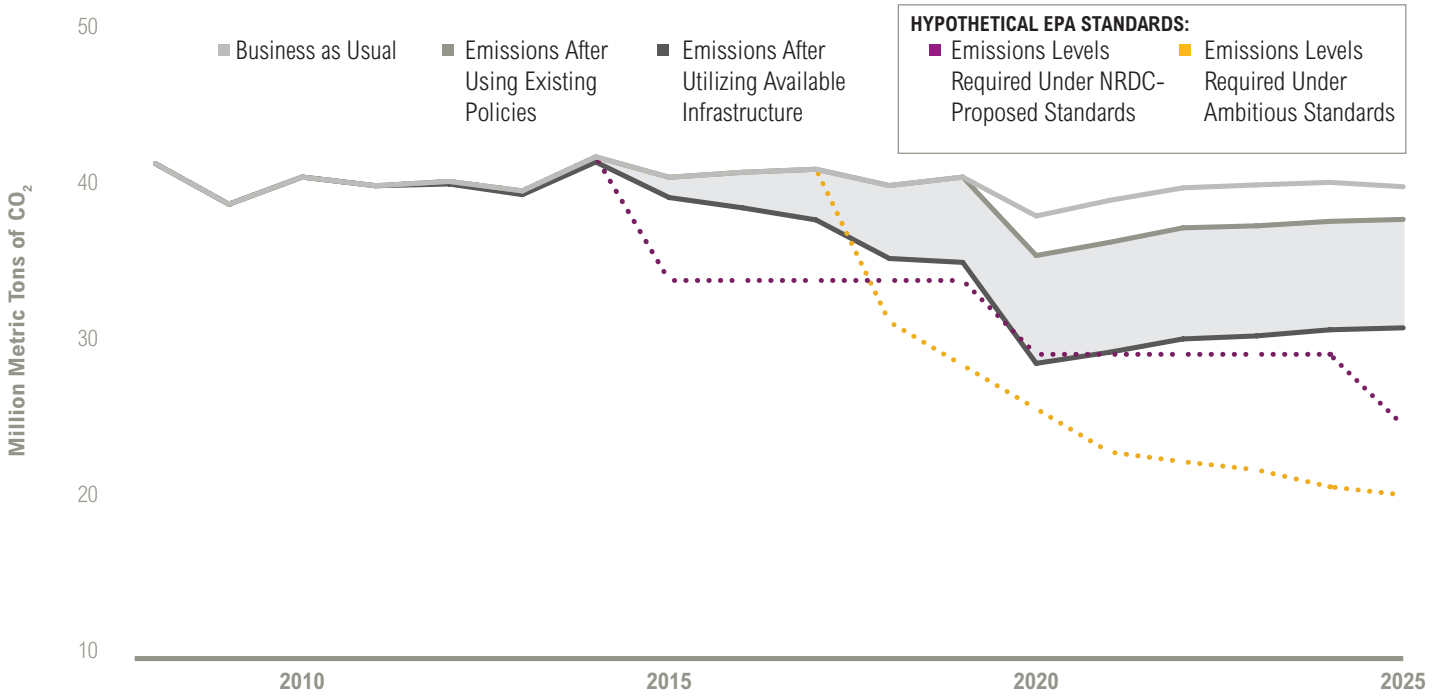
CO_2 reduction opportunities *using existing policies* include:

- **Meeting renewable energy targets.**[10] Colorado's renewable standard requires some of the electricity sold by its electricity producers to come from renewables: 30 percent for investor-owned utilities, 20 percent for the largest electric cooperatives, and 10 percent for smaller electric cooperatives and large municipalities. *Meeting this requirement by adding new renewable generation in Colorado will reduce CO_2 emissions by 7 percent below 2011 levels in 2020.*
- **Meeting energy efficiency targets.** Colorado's efficiency standard requires utilities to implement programs that help customers save energy. *Meeting this standard can reduce Colorado's CO_2 emissions by 5 percent below 2011 levels in 2020.*[11]

CO_2 reduction opportunities *using available infrastructure* include:

- **Using more combined heat and power (CHP).** Colorado has the potential to use more CHP systems—which use waste heat to generate electricity more efficiently than the average power plant—at sites like universities, hospitals, and manufacturing facilities. *Increasing the use of CHP by about 30 percent could reduce CO_2 emissions by 2 percent below 2011 levels in 2020.*
- **Using more gas.** Colorado's most efficient natural gas plants—combined cycle (NGCC) units—generated much less electricity than they were capable of

Figure 1 | **Colorado Carbon Dioxide Reduction Opportunities for Power Sector Compliance Under The Clean Air Act**



Note: EPA has not yet proposed a national emissions standard for existing power plants. For purposes of illustration, this analysis shows emissions reductions that would occur if EPA adopted the Natural Resources Defense Council's (NRDC) proposed standards for existing power plants that would require CO_2 emissions reductions in Colorado of 28 percent below 2011 levels in 2020. We also show the emissions reductions that would occur if EPA adopted a more ambitious "go-getter" reduction schedule, which aligns with a national reduction pathway necessary to meet the Obama Administration's goal of reducing emissions 17 percent below 2005 levels by 2020.[12] National power sector emissions in the "go-getter" scenario drop 38 percent from 2005 to 2020; we show the equivalent percent reductions applied to Colorado's power sector (37 percent from 2011 to 2020). See endnote 9 for additional explanation.

producing in 2011. *Running existing NGCC plants at 75 percent can reduce CO_2 emissions by 15 percent below 2011 levels in 2020.*

- **Increasing existing coal plant efficiency.** Existing coal plants could save energy by upgrading their equipment and making other operational improvements. *Increasing coal plant efficiency by 2.5 percent could reduce CO_2 emissions by 1 percent below 2011 levels by 2020.*

Colorado could achieve even greater long-term emissions reductions—and put itself in a better position to meet or exceed stringent standards—by expanding existing policies. By taking the actions listed below, which would likely require additional legislation, Colorado can reduce power sector CO_2 emissions by an additional 16 percent in the next six years, to 45 percent below 2011 levels by 2020 and 52 percent below 2011 levels by 2030.[13] Reductions of this magnitude would exceed those required by potentially stringent standards for existing power plants.

- Accelerating and expanding the EERS (-13 percent in 2020 compared to 2011 levels).
- Further increasing CHP capacity at commercial and industrial facilities (-3 percent in 2020 compared to 2011 levels).

In addition, the reductions shown here do not reflect the effects of Xcel Energy switching two coal plants to simple-cycle natural gas plants as part of the Clean Air, Clean Jobs Act. Fuel-switching at these two plants will drive additional emissions reductions beyond those shown in Figure 1.

OPPORTUNITIES IN DETAIL

Existing and Expanded Energy Efficiency Resource Standards. In 2007, Colorado enacted an energy efficiency resource standard, which required investor-owned utilities to achieve electricity savings of at least 5 percent of 2006 sales by 2018. In 2011, the Colorado Public Utility Commission (PUC) chose to increase the annual savings

goals for Colorado's largest utility, Xcel Energy, to about 1 percent in 2012, ramping up to 1.7 percent in 2020.[14,15] The American Council for an Energy-Efficient Economy (ACEEE) estimates that meeting the standard will require about 1.4 percent annual electricity savings between 2012 and 2020.[16] Colorado's utilities offer a variety of energy saving programs to all customers in order to meet their targets, including financial incentives for their customers to purchase more efficient equipment and to engage in demand response. Xcel Energy found that benefits of meeting its standard have exceeded the costs by over $200 million each year since 2009.[17] In 2012, the standard's benefits were more than double its costs, saving Xcel's electricity customers over $300 million.[18] If Colorado enacts new legislation to ramp up its annual electricity savings to 2 percent per year beginning in 2015 and beyond and apply the standard to all utilities in the state, it can reduce power sector CO_2 emissions by an additional 13 percent below 2011 levels by 2020.

Existing Renewable Energy Standards. In 2004, Colorado passed a renewable energy standard requiring 10 percent of electricity sold by utilities with more than 40,000 customers to be generated from renewable sources by 2015. Since 2004, the state has expanded the target to include smaller utilities and increased the target for certain electricity providers: investor-owned utilities must meet a 30 percent standard by 2020; municipal utilities serving more than 40,000 customers and small electric cooperatives must meet a 10 percent standard by 2020; and in 2013, the standard for large electric cooperatives was raised to 20 percent by 2020.[19] To meet its standards, Colorado's utilities will need to increase renewable sales by nearly 1 percent per year on average between 2011 and 2020. In-state renewable generation has been on the rise, growing over 100 percent between 2007 and 2011 to comprise 14 percent of total generation. Nearly 500 megawatts (MW) of new wind capacity and solar capacity were added in 2012 or planned for 2013.[20] By meeting its renewable standard through in-state generation,[21] Colorado can reduce its power sector emissions by an additional 7 percent in 2020 compared to 2011 levels beyond the reductions captured in the *AEO 2012* reference case.

Increasing CHP at Commercial and Industrial Facilities. As of July 2013, Colorado had 680 MW of installed CHP, less than half of its technical potential according to estimates by ICF International.[22,23] The majority of this capacity was added before 2000, with only about 90 MW of new CHP added since then. While Colorado has favorable interconnection standards and includes renewable-fired CHP as an eligible resource under the distributed generation carve-out in its RPS, the state has the opportunity to take additional steps to encourage CHP deployment.[24] The State and Local Energy Efficiency Action Network found that many industrial facilities can achieve annual energy savings of 15 percent or greater with systems that pay for themselves in less than three years.[25]

If the state ramped up CHP capacity on a path to achieve 25 percent of additional technical potential for new CHP by 2030 (for a total of 46 percent of total technical potential), it would reduce power sector CO_2 emissions by 2 percent in 2020 compared to 2011 levels. If the state could achieve 50 percent of additional technical potential by 2030 (achieving 64 percent of total technical potential), it would reduce power sector emissions by 3 percent in 2020 compared to 2011 levels.

Utilizing Slack Natural Gas Capacity. According to EIA

Box 2 | About This Series

In *Can The U.S. Get There From Here?*, WRI identified four key actions the Obama Administration must take in the absence of congressional action in order to meet the U.S. commitment to reducing greenhouse gas (GHG) emissions by 17 percent below 2005 levels by 2020. These actions include setting performance standards for existing power plants, reducing consumption of hydrofluorocarbons, reducing fugitive methane emissions from natural gas systems, and increasing energy efficiency. Of these four actions, the greatest opportunity for reductions comes from the power sector. In his recently announced Climate Action Plan, President Obama has directed EPA to work expeditiously to finalize carbon dioxide (CO_2) emissions standards for new power plants and adopt standards for existing power plants. As states prepare to comply with these standards, it will be necessary to understand available opportunities for reducing CO_2 emissions from the power sector. This series of fact sheets aims to shed light on these opportunities by illustrating the CO_2 emissions reduction potential from measures in a variety of states. We show how these emissions savings stack up against the reductions that could be required under forthcoming standards. This series is based on WRI analysis conducted using publicly available data. See the appendix for additional information on our methodology and modeling assumptions.[26]

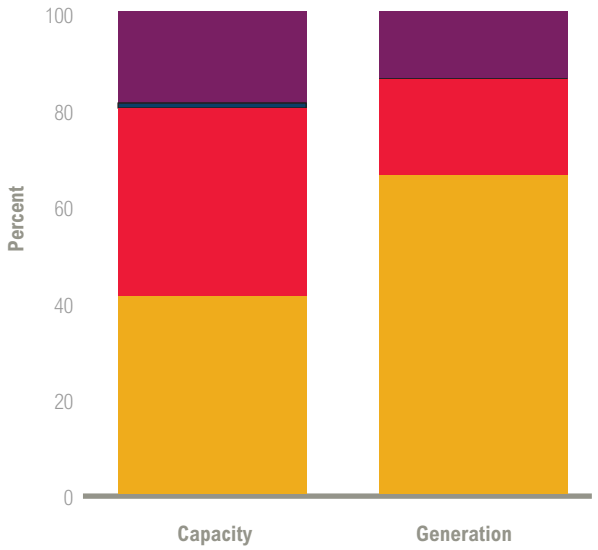
data, the capacity factor of Colorado's existing combined cycle natural gas fleet was 43 percent in 2011—meaning that these plants generated much less electricity than they are capable of producing.[27] Increasing the capacity factor of these existing units to 75 percent would cut power sector CO_2 emissions by 15 percent in 2020 compared to 2011 levels.[28,29] Much of Colorado's natural gas fleet is currently being used to help integrate renewables onto the grid. Running all NGCC units at 75 percent capacity could limit their ability to be used for this purpose. However, Colorado also has 3 gigawatts (GW) of simple-cycle natural gas capacity that could serve as backup generation for renewables. Fuel-switching from coal to simple-cycle natural gas at existing coal plants—an option already being pursued by Xcel Energy—could provide additional gas capacity to provide backup generation for renewables while also reducing emissions.[30] (See Box 3 for additional information on Colorado's power sector.)

Increasing Efficiency at Existing Coal Plants. According to the National Energy Technology Laboratory (NETL) and researchers at Lehigh University, it is likely that the

Box 3 | Colorado Power Sector Profile

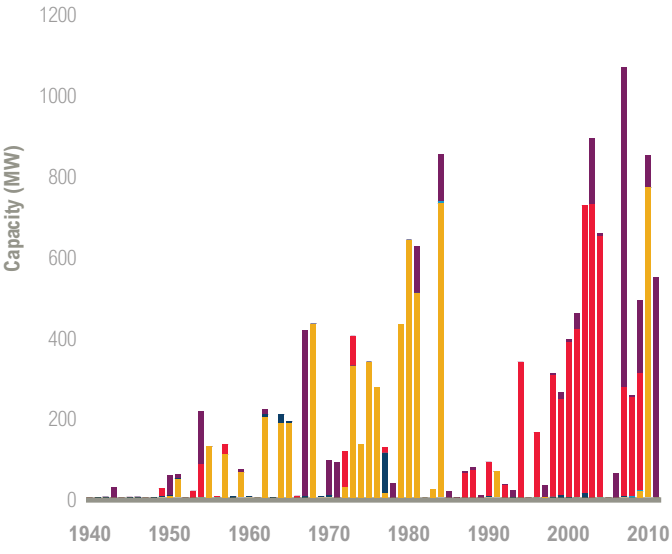
Until the mid-1980s, most new capacity being built in Colorado was coal-fired. Since then, natural gas has comprised the bulk of new capacity additions.[31] Renewable generating capacity has grown significantly since 2009, and over 500 MW of new wind and solar capacity was added in 2012. (Note that the chart below goes through 2011.) Despite increased use of renewables between 2005 and 2011, coal generation fell by only 4 percent as overall electricity demand rose in the state. Coal comprised 66 percent of in-state generation in 2011, while natural gas and renewable sources comprised 20 percent and 14 percent, respectively. A significant amount of coal capacity is slated for retirement or conversion in coming years. As part of Colorado's Clean Air-Clean Jobs Act, Xcel Energy plans to retire over 500 MW of coal in the state by 2017 and plans to fuel-switch from coal to natural gas at two additional units (460 MW capacity).[32] In 2011, Colorado contributed 2 percent of total U.S. CO_2 emissions in the power sector and 1 percent of electricity generation, with a state CO_2 emissions intensity of 1,680 lbs. per MWh. While this is considerably higher than the U.S. average (about 1,200 lbs. per MWh), our analysis shows that by using existing policies and infrastructure, Colorado could reduce the carbon intensity of its power sector to around 1,230 lbs. per MWh by 2020.

Colorado Generation and Generating Capacity by Fuel, 2011



Source: U.S. Energy Information Administration Form EIA-860 and Annual Energy Review

New Electric Generating Capacity Additions by Fuel Type



Source: U.S. Energy Information Administration Form EIA-860, which includes existing electric generating units at plants with at least 1 MW capacity (electric utilities, independent power producers, and combined heat and power plants) that are connected to a power grid. Data represents installed summer capacity.

BOTH CHARTS USE THE FOLLOWING LEGEND: Coal | Natural Gas | Oil | Other Fossil | Renewables

existing coal fleet could achieve a 5 percent increase in efficiency on average.[33] For purposes of this analysis, we conservatively assume that Colorado's coal fleet would achieve a 2.5 percent increase in efficiency, half of these potential levels. While there are high upfront costs associated with refurbishing existing coal units, the resulting increase in unit efficiency will lead to annual fuel savings.[34] Existing coal plants can increase efficiency through refurbishment and improved operation and maintenance practices, though the actual efficiency potential depends on plant age and other physical limitations.[35,36] Another option to reduce the emissions intensity of a coal plant is co-firing with natural gas using the igniters that are already built into many existing pulverized coal boilers.[37] In addition to reducing emissions intensity, co-firing with natural gas could also provide backup generation for renewables, an option that is not viable with coal-fired units. These actions can lead to reductions in power sector CO_2 emissions of up to 1 percent compared to 2011 levels in 2020.

OUTLOOK FOR COLORADO

Colorado has already put measures in place that will achieve CO_2 emissions reductions and has the opportunity to achieve greater reductions building off of its progress to date. The Clean Air, Clean Jobs Act, adopted in 2010, is already leading to a shift away from coal generation and reducing emissions in Colorado. By meeting the requirements of its existing policies—including Clean Air, Clean Jobs as well as renewable energy and energy efficiency standards—and taking advantage of available infrastructure and underutilized resources, Colorado is in a good position to comply with moderately ambitious standards for existing power plants. Colorado could place itself in a better position to meet more stringent standards by expanding on its existing policies. Through federal and state-level actions, the United States can meet its commitment to reduce emissions 17 percent below 2005 levels by 2020.

ENDNOTES

1. Data reflect emissions from electric utilities and independent power producers.
2. According to the Energy Information Administration's (EIA) *2013 Annual Energy Outlook* (*AEO 2013*) Reference Case, CO_2 emissions from the power sector will be 14 percent below 2005 levels by 2020 and only 5 percent below 2005 levels by 2035. See U.S. Department of Energy/Energy Information Administration. 2013. "Energy-Related Carbon Dioxide Emissions by Sector and Source, United States, Reference Case." In U.S. DOE/EIA. *Annual Energy Outlook 2013*. Washington, D.C.: Government Printing Office. Accessible at: <http://www.eia.gov/forecasts/aeo/>.
3. For more information, see <http://www2.epa.gov/carbon-pollution-standards/2013-proposed-carbon-pollution-standard-new-power-plants>.
4. U.S. Department of Energy/Energy Information Administration. 2013. "Electric Generating Capacity, Reference Case." In U.S. DOE/EIA. 2013. *Annual Energy Outlook 2013*. Washington, D.C.: Government Printing Office. Accessible at: <http://www.eia.gov/forecasts/aeo/>. For more details, see also: <http://www.wri.org/publication/us-electricity-markets-increasingly-favor-alternatives-to-coal>.
5. *AEO 2012* does not explicitly model state EERS. We conservatively assume that these standards would be incorporated into the reference case through regional demand trends.
6. In addition to the planned coal plant retirements, the Clean Air, Clean Jobs Act (Accessible at: <http://www.leg.state.co.us/clics/clics2010a/csl.nsf/fsbillcont/0CA296732C8CEF4D872576E400641B74?Open&file=1365_ren.pdf>) also calls for switching two coal plants (total generating capacity of 461 MW) into simple-cycle natural gas plants. These switches are not captured in the *AEO 2012* and are not included in our analysis, and would likely lead to further reductions beyond what we present here.
7. *AEO 2012* models compliance with renewable portfolio standards through a combination of in-state generation and purchases of renewable energy credits (RECs) from out of state. For purposes of this analysis, we assume that in the face of new CO_2 standards, all renewable electricity generated for compliance with the state's RPS occurs in-state, and adjust the reference case accordingly. Nearly all of the renewable generation used to comply with Colorado's RPS to date has been generated in-state, and this is expected to continue (personal communication, John Nielsen, Western Resource Advocates).
8. The sum of reductions from the individual measures listed—along with the reductions captured in the reference case—may not match this total due to rounding. We calculated emissions reductions for existing policies using the annual reference case emissions rates for each fuel type. See the appendix for additional information on the assumptions and methodology used for this analysis (Accessible at: <http://www.wri.org/sites/default/files/power_sector_opportunities_for_reducing_carbon_dioxide_emissions_methodology_2.pdf>).
9. EPA has not yet proposed a national emissions standard for existing power plants. To illustrate the possible stringency of the future standards, this analysis shows emissions reductions for two scenarios. Proposed standards by the Natural Resources Defense Council (Accessible at: <http://www.nrdc.org/air/pollution-standards/files/pollution-standards-report.pdf>) would result in GHG emissions reductions in Colorado of 28 percent below 2011 levels in 2020. In WRI's *Can the U.S. Get There From Here?*, which focuses on reductions from 2005 levels, the most stringent scenario (the "go-getter" scenario) would achieve a 38 percent reduction from the power sector nationally between 2005 and 2020. For Colorado, this is equivalent to a 37 percent reduction from 2011 levels.

(It is unlikely that EPA standards would require identical reductions in each state, given the wide variation in emission intensities when the standards will be implemented.)

10. Projections based on *AEO 2012* regional generation show in-state renewable generation sufficient to meet Colorado's RPS through 2019, after which EIA projects the remainder of the renewable requirement will be met through purchases of renewable energy credits from out-of-state generation. We adjust the reference case to assume that the entire RPS requirement is met through in-state generation. As previously mentioned, nearly all of the renewable generation used to comply with Colorado's RPS to date has been generated in-state, and state experts expect this to continue in the future.
11. We assume the CO_2 savings associated with the existing energy efficiency standard are incorporated in the *AEO 2012* reference case.
12. *Can The U.S. Get There From Here? Using Existing Federal Laws and State Action to Reduce Greenhouse Gas Emissions*. Nicholas Bianco, Franz Litz, Kristin Meek, and Rebecca Gasper. World Resources Institute. February 2013. Accessible at: <http://pdf.wri.org/can_us_get_there_from_here.pdf>.
13. Emissions reductions calculated using the emissions rate resulting from the adjusted reference case projection that includes Colorado's EERS and RPS policies. Reductions listed as a result of expanded policies are additional to reductions from existing policies.
14. *House Bill 07-1037*, Accessible at: <http://www.leg.state.co.us/CLICS/CLICS2007A/csl.nsf/fsbillcont3/5EA2048E8A50B21287257251007B8474?Open&file=1037_enr.pdf>.
15. We assume that all CO_2 benefits from meeting the existing energy efficiency resource standard are captured in the *AEO 2012* reference case.
16. *State Energy Efficiency Scorecard 2012*. ACEEE. Accessible at: <http://aceee.org/research-report/e12c>.
17. *Demand Side Management Annual Status Reports 2009-2013*. Xcel Energy. Accessible at: <https://www.xcelenergy.com/About_Us/Rates_&_Regulations/Regulatory_Filings/CO_DSM>.
18. *Demand Side Management Annual Status Report*. Xcel Energy, April 2013, Accessible at: <http://www.xcelenergy.com/staticfiles/xe/Regulatory/Regulatory%20PDFs/CO-DSM-2012-Annual-Status-Report.pdf>.
19. *Senate Bill 252*, Accessible at: <http://www.leg.state.co.us/clics/clics2013a/csl.nsf/fsbillcont3/D1B329AEB8681D4D87257B3900716761?Open&file=252_01.pdf>.
20. EIA-860 database. Accessible at: <http://www.eia.gov/electricity/data/eia860/>.
21. For purposes of this analysis, we assume that in the face of new CO_2 standards, all renewable electricity generated for compliance with the state's RPS occurs in-state. See endnote 7 for additional information.
22. *ICF International CHP database,* Accessible at: <http://www.eea-inc.com/chpdata/>.
23. ICF International estimates of technical potential provided for analysis by ACEEE. For more details, see: <http://www.aceee.org/sites/default/files/publications/researchreports/ie123.pdf>.
24. In 2013, Colorado ranked 19th on ACEEE's *State Energy Efficiency Scorecard* rating based on its adoption of measures to encourage deployment of CHP systems. Standby tariffs may pose a barrier to additional CHP development in the state. Xcel Energy is currently developing a recycled energy incentive program that would support some types of CHP. Additional measures the state could take include inclusion of CHP in efficiency standards, additional financial incentives, favorable net metering regulations, emissions regulations, technical support and guidance, and other supportive programs and policies.
25. *Industrial Energy Efficiency and Combined Heat and Power*. SEE Action Network, July 2012, Accessible at: <http://www1.eere.energy.gov/seeaction/pdfs/industrial_factsheet.pdf>.
26. *Power Sector Opportunities For Reducing Carbon Dioxide Emissions. Appendix A: Detailed Overview of Methods*. World Resources Institute. 2013. Washington, DC: World Resources Institute. Accessible at: <http://www.wri.org/sites/default/files/power_sector_opportunities_for_reducing_carbon_dioxide_emissions_methodology_2.pdf>.
27. WRI estimates based on data from U.S. Energy Information Administration, *EIA-923 Generation and Fuel Data*, Accessible at: <http://www.eia.gov/electricity/data/eia923/>; and *EIA-860 Annual Electric Generator Data*, Accessible at: <http://www.eia.gov/electricity/data/eia860/>.
28. NGCC units are designed to be operated up to 85 percent capacity (see <http://mitei.mit.edu/system/files/NaturalGas_Chapter4_Electricity.pdf>), but actual maximum capacity factors may differ among units. We assume a maximum capacity factor of 75 percent to remain conservative.
29. We did not account for the associated increases in methane associated with the increased production of natural gas due to a higher demand for the fuel. Going forward, industry should work with EPA to reduce methane leakage rates from natural gas systems. For additional information see: <http://www.wri.org/publication/clearing-the-air>.
30. As part of the Clean Air-Clean Jobs Act, Xcel Energy plans to fuel-switch from coal to natural gas at two of its existing units, representing a total of over 450 MW in capacity, by 2017. These conversions are not captured in the *AEO 2012* reference case. While we do not model these conversions explicitly, the measures that we consider here reduce coal generation by 46 percent and increase natural gas generation by nearly 100 percent between 2011 and 2020. This is additional to the effects of over 500 MW of coal retirements and over 600 MW of new NGCC capacity additions through 2020 that are already captured in the reference case. If more coal capacity in the state is converted to natural gas, additional CO_2 savings could be possible beyond what we have captured in this analysis, particularly if fuel-switching is achieved with combined cycle repowering.
31. Unless otherwise indicated, we relied upon the U.S. Energy Information Administration *Annual Energy Review* and *Form EIA-860* for data reported in Box 3.
32. For more information, see: <http://www.xcelenergy.com/Environment/Doing_Our_Part/Clean_Air_Projects/Colorado_Clean_Air_-_Clean_Jobs_Plan>.
33. *Improving the Efficiency of Coal-Fired Power Plants for Near Term Greenhouse Gas Emissions Reductions*. Phil DiPetro and Katrina Krulla. 2010. National Energy Technology Laboratory, Office of Systems, Analyses and Planning. DOE/NETL-2010/1411. Accessible at: <http://www.netl.doe.gov/energy-analyses/pubs/ImpCFPPGHGRdctns_0410.pdf>. *Reducing CO_2 Emissions by Improving the Efficiency of the Existing Coal-fired Power Plant Fleet.* Chris Nichols, Gregson Vaux, Connie Zaremsky, James Murphy, and Massood Ramezan. 2008. National Energy Technology Laboratory, Office of Systems, Analyses, and Planning, and Research and Development Solutions, LLC. DOE/NETL-2008/1329. Accessible at: <http://www.netl.doe.gov/energy-analyses/pubs/CFPP%20Efficiency-FINAL.pdf>. *Analyses Show Benefits of Improving Unit Heat Rate as Part of a Carbon Mitigation Strategy.* Lehigh Energy Update 28 (1), February 2010. Accessible at: <http://www.lehigh.edu/~inenr/leu/leu_65.pdf>.
34. For example, the National Energy Technology Laboratory found a payback period of less than 4 years for a refurbishment technology that achieves a 2 percent heat rate improvement. For more information, see *Benefits of the Big Bend Power Station Project, National Energy Technology Laboratory*. Accessible at: <http://www.netl.doe.gov/technologies/coalpower/cctc/ccpi/pubs/tampa.pdf>; and *Analyses Show Benefits of Improving Unit Heat Rate as Part of a Carbon Mitigation Strategy*. Lehigh

Energy Update 28 (1), February 2010. Accessible at: <http://www.lehigh.edu/~inenr/leu/leu_65.pdf>.
35. *Improving the Efficiency of Coal-Fired Power Plants for Near Term Greenhouse Gas Emissions Reductions*. Phil DiPetro and Katrina Krulla. 2010. National Energy Technology Laboratory, Office of Systems, Analyses and Planning. DOE/NETL-2010/1411. Accessible at: <http://www.netl.doe.gov/energy-analyses/pubs/ImpCFPPGHGRdctns_0410.pdf>.
36. *Regulating Greenhouse Gas Emissions Under the Clean Air Act*. 73 Register §147(2008). Accessible at: <http://www.gpo.gov/fdsys/pkg/FR-2008-07-30/pdf/E8-16432.pdf>.
37. Personal communication with Tomas Carbonell, Environmental Defense Fund, July 12, 2013.
38. *Power Sector Opportunities For Reducing Carbon Dioxide Emissions. Appendix A: Detailed Overview of Methods*. World Resources Institute. 2013. Washington, DC: World Resources Institute. Accessible at: <http://www.wri.org/sites/default/files/power_sector_opportunities_for_reducing_carbon_dioxide_emissions_methodology_2.pdf>.

POLICY FRAMEWORK AND INTERACTION

This analysis assumes the existing policies and other reduction opportunities listed above are fully implemented. Depending on the combination of measures actually implemented by Colorado, each will have different impacts on the generation mix and resulting emissions. For example, increasing the efficiency of existing coal-fired power plants results in fewer emissions reductions in this analysis than would be the case if it were considered in isolation, because implementation of the EERS and RPS and an increase in natural gas generation all decrease the state's coal-fired generation. The emissions reductions presented in the text are a result of each policy in combination with all other policies. We first applied the existing RPS to calculate an adjusted reference case assuming the standard is met through in-state generation. Next, we increased CHP capacity and increased utilization of existing natural gas capacity compared to this adjusted reference case. Last, we increased the efficiency of any remaining coal plants. When considering the expanded policies, we applied the expanded EERS followed by increased CHP capacity, and then applied the expanded RPS to the resulting adjusted demand.

Equally as important is the policy framework, which will define how each of these measures counts toward compliance under EPA's standards. We assumed that the emissions reductions from each measure would count directly toward the standard. State measures may be counted differently in the actual standards, thus actual compliance levels could potentially be greater or less than what was modeled. See the appendix for additional information on our methodology and modeling assumptions.[38]

ABOUT WRI

WRI is a global research organization that works closely with leaders to turn big ideas into action to sustain a healthy environment—the foundation of economic opportunity and human well-being.